

3. Re Reference R3, paragraph 3 - "Claim Rejections – 35 USC § 112"

First, as an aid to correct comprehension, we offer in Appendix I a brief explanation of engineering terms related to 'radiation view factor', terms that are used in the disclosure of Reference R1 and also extensively in the instant letter including in the instant section. It would be hard to overemphasize the importance of thoroughly understanding Appendix 1.

Following that, we propose that Claim 3 be allowed to stand, and not be rejected, for the following reasons.

Claim 3 is not indefinite as stated in paragraph 3 of Reference R3. The phrase "a radiation view factor from said opposed surface to said opposed surface" in the last three lines of Claim 3 refers to thermal radiation emitted from said opposed surface (which is the non-sun facing surface of the sun blocker component) and subsequently incident upon and absorbed by (the same) said opposed surface. For example, a concave surface has a non-zero radiation view factor to itself (i.e. radiation self-view factor) due to non-zero solid angles subtended at parts of the concave surface by other parts of the same concave surface.

A non-zero radiation self-view factor of said opposed surface of the sun blocker component reduces the radiation view factor from the thermal radiator surface to deep space, since thermal radiation is trapped in multi-path interactions at said opposed surface and eventually re-emitted back towards the source thermal radiator surface.

Claim 3 specifies a spacecraft including a sun blocker component that features "...a high radiation view factor from the thermal radiator surfaceto deep space...", and thereby a high capability for cooling the thermal radiator surface.

The radiation view factor from the thermal radiator surface to deep space is limited by absorptions and re-emissions of thermal radiation at said opposed surface. An industrially useful, high, radiation view factor from the thermal radiator surface to deep space can only be achieved by a design that also features a low radiation self-view factor for said opposed surface of the sun blocker component. Part of the energy radiated from the thermal radiator surface and incident on said opposed surface of the sun blocker component is reflected by or re-emitted towards deep space from said opposed surface of the sun blocker component. However, if said opposed surface of the sun blocker component has a non-zero radiation self-view factor, for example is concave, a result is less net energy rejected from the thermal radiator surface towards deep space, and thereby a lowered cooling capability for the thermal radiator surface.

For example, USPN 4,725,023 to Shiki teaches of a spacecraft with a "shading plate" (21) the cross section of which is semi-circular due to conformance with the main body of a spinning, drum-shaped spacecraft. The radiation view factor towards deep space from points on the spacecraft behind the backside (non sun-facing side) of the shading plate is severely limited by the high radiation self-view factor of the backside surface of the shading plate, as well as by direct blockage by the shading plate. For industrial usefulness, the backside surface of the sunshade must be as flat as possible or even convex.

4. Re Reference R3, paragraph 4 - "Claim Rejections – 35 USC § 103"

We note the quotation of 35 USC § 103.

5. Re Reference R3, paragraph 5 - "Claim Rejections – 35 USC § 103"

For the following reasons, we propose that Claims 1-3, 7-9, and 11 be allowed to stand, and not be rejected.

c. Re Claims 1 and 3

Consider the following three options for improving the cooling capability of a thermal radiator used on a spacecraft for rejecting heat to deep space:

- **Option (1)**: to increase the area of the radiator,
- **Option (2)**: to increase the effective radiation view factor from the thermal radiator to deep space,
- **Option (3)**: to reduce the amount of external energy reaching the thermal radiator.

Potential for improvement through **Option (1)** is limited in practice by constraints on mass, size, complexity/reliability, cost, etc for the spacecraft. Generally, **Option (2)** and **Option (3)** conflict mightily with each other, because while a sun blocker device can be designed to reduce unwanted external energy, such as from incident sunrays, it also reduces the effective radiation view factor from the thermal radiator surface to deep space.

Critical, novel features and inventive steps unique to the disclosure of Reference R1, and summarized in paragraphs **A** and **B** on page 7 and in sections 7.2, 7.3 and 7.3.1 herein, constitute the only means for implementing **Option (3)** without significantly reducing the effective radiation view factor from the thermal radiator to deep space (that is related to **Option (2)**). The sun shields of prior art are absent said critical, novel features and inventive steps unique to the disclosure of Reference R1.

While USPN 5,372,183 to Strickberger teaches of insulation for prevention of heat transfer into and out of the central body of a spacecraft, neither USPN 5,372,183 nor USPN 4,725,023 to Shiki teach of use of insulation means for improving heat rejection capability from a thermal radiator surface on a spacecraft, and in particular do not teach of using insulation means within a sun blocker component.

Also, while prior art that includes sun blocker components (said prior art being referenced and summarized in the disclosure of Reference R1, and said prior art including USPN 4,725,023 to Shiki) is extensive and was written by experts who far surpass ordinary skill in the art, nevertheless said prior art does not teach of either **(I)** presence of thermal insulation material within a sun blocker component or **(II)** co-planarity of component areas of the non sun-facing surface of a sun blocker component. To the extent that said prior art works or is effective as intended – and much of it does not work as intended and is not effective as intended, as evidenced in our discussions later herein – said prior art depends upon separate and distinct features that do not include critical, novel features and

inventive steps unique to the disclosure of Reference R1 including those in Claims 1 and 3 in the disclosure of Reference R1 which are summarized under paragraphs **A** and **B** on page 7 and in sections 7.2, 7.3 and 7.3.1 herein.

Said prior art either does not work or has optimum performance greatly lower than achievable with the fundamentally distinct and superior design of the disclosure of Reference R1.

Furthermore, despite said prior art, the problem of low efficiency of thermal radiators exposed to solar energy on spacecraft in space remained an accepted, 'inescapable fact of life' within the spacecraft industry up to the date of the priority document for Reference R1. The teachings of USPN 4,725,023 to Shiki constitute one example of several that do not work at all - for several reasons as explained in paragraphs following on from paragraphs **A** and **B** on page 7 herein. The remainder of said prior art that attempted to solve the problem, all authored by experts in the art, all depended on inferior principles and designs, that are separate and distinct relative to the disclosure of Reference R1, and were all fundamentally incapable, regardless of increases in efficiency of their stated means, of attaining performance levels comparable with the practical potential of the invention according to the disclosure of Reference R1.

In thermal interactions within many-body configurations, such as those that the disclosure of Reference R1 addresses, the involved phenomena, causes, effects, magnitudes, significance, efficiency, and means of improvement are not obvious to one of ordinary skill in the art; and even experts in the art are obliged to probe and analyze them using sophisticated numerical simulations on digital computers.

We proposes that in the case of the disclosure of Reference R1 what may now, with the advantage of hindsight, seem obvious to one of ordinary skill in the art in fact took unusually clear, perceptive, and inventive minds that also probed the right issues, asked the right questions, and analyzed the right configurations in complex systems that had eluded/defeated all experts in the art for several decades previously. The significance of (a) thermal insulation material between the sun facing and opposed surfaces of the sun blocker component and (b) the configuration of the sun blocker component was not appreciated by anyone regardless of levels of skill in the art; and only less significant, separate, and distinct characteristics were appreciated, discussed, and taught up to the date of Reference R2, i.e. the priority document for Reference R1.

Accordingly, already it is clear that it was not and would not have been obvious to one of ordinary skill in the art to have applied the teachings of Caplin and Strickberger into the device of Shiki so as to allow for the radiators of Caplin to become more effective by shielding them from external heat with the blockers of Shiki and also by using insulation of Strickberger in the blockers so as to increase their effectiveness and the efficiency of the entire system.

In contrast, Claims 1, 2, and 3 in the disclosure of Reference R1 teach of:

- A.** use of insulation material, including MLI, between the sun-facing and opposed surfaces of a sun blocker component for purposes including the following:
 - i). to achieve a high value of “effective radiation view factor” from the thermal radiator to deep space. Note that without a high effective radiation view factor from the thermal radiator surface to deep space, the thermal radiator has poor cooling capability. Note also that the effect of insulating material beneath said opposed surface upon thermal energy that is emitted by the thermal radiator and then absorbed by said opposed surface is to force re-emission of the thermal energy, mostly towards deep space, thereby adding to specular reflection by said opposed surface of thermal energy from the thermal radiator, and also thereby resulting in a high value of effective radiation view factor from the thermal radiator to deep space.
 - ii). to prevent solar energy absorbed at the sun-facing surface of a sun blocker component from passing through to the backside (non sun-facing) surface and in turn being radiated towards the thermal radiator surface.
- B.** use of co-planarity of component areas of said opposed surface in order to achieve a high value of “effective radiation view factor” from the thermal radiator to deep space.

Neither of preceding teachings **A** and **B** is taught or conceived of in Strickberger’s design.

We acknowledge that, as you have indicated, application of thermal radiators on spacecraft is well known in the art. However, we also note that regarding USPN 5,806,800, while Caplin teaches therein how to increase surface area and thereby cooling capability of a thermal radiator on a spacecraft (by following the aforementioned **Option1** on page 5 herein), he does not teach of either increasing the effective radiation view factor from the thermal radiator to deep space or of blocking solar energy from reaching the thermal radiator (i.e. he does not teach of the aforementioned Options 2 or 3 on page 5 herein, respectively), which are taught of in the disclosure of Reference R1.

The design in USPN 4,725,023 to Shiki is representative of prior-art attempts at the aforementioned **Option (3)** on page 5 herein – none of which prior-art attempts claim or describe the aforementioned critical, novel features and inventive steps unique to the disclosure of Reference R1 for increasing heat rejection from the thermal radiator to deep space. The design to Shiki is one among several designs in related prior art that spectacularly fail to achieve their goals. Not only does the shading plate (21) therein fail to increase heat rejection to deep space from parts of the spacecraft that it shades, in fact it also drastically decreases that heat rejection and, furthermore, also subjects spacecraft equipment rotating behind it to great cyclical variations in thermal environment, at the frequency of rotation!

Consequently, there is no issue of the disclosure of Reference R1 simply optimizing effectiveness and efficiency of spacecraft by Shiki and others in prior art. The teachings of the disclosure of Reference R1 are novel and distinct and are fundamentally superior to prior art.

In USPN 4,725,023 to Shiki, the backside (non sun-facing) surface of the shading plate (21) radiates a great flux of solar energy towards the thermal radiator surface(s) on the spacecraft because it quickly reaches an equilibrium temperature very nearly equal to the temperature of the sun-facing surface, due to solar energy absorbed at the sun-facing surface and lack of thermal insulation between the sun-facing and back surfaces of the shading plate. Furthermore, the (non sun-facing) surface of the shading plate greatly reduces the effective radiation view factor from the thermal radiator towards deep space in two ways:

- iii). by greatly blocking the direct radiation-view from the thermal radiator to deep space, and
- iv). by trapping (due to the very high self-view factor of the said non sun-facing surface) of thermal radiation that originates from the thermal radiator and subsequently re-emitting the energy back towards the thermal radiator.

Furthermore, because the spacecraft rotates while the shading plate is held inertially oriented toward the Sun, spacecraft equipment behind the shading plate is alternately subjected to the thermal environments of deep space (very cold) and of the (very hot) non sun-facing surface of the shading plate, at the frequency of rotation.

Claim 1 in the disclosure of Reference R1 claims a critical characteristic for material in the sun blocker component. Claim 3 in the disclosure of Reference R1 claims a critical configuration characteristic for the non-sun-facing surface sun blocker component.

We propose that Claims 1 and 3 in the disclosure of Reference R1 are novel and inventive, particularly with respect to prior art, and that they be allowed to stand, and not be rejected.

Please note that in Appendix 2 hereto we provide evidence of the validity of the priority claimed.

d. Re Claim 2

Claim 2 is dependent on Claim 1, the novelty and inventiveness of which have been outlined previously herein.

Furthermore, from the preceding section (i.e. "c. Re Claims 1 and 3") it may readily be appreciated that it was not and would not have been obvious to one of ordinary skill in the art to have applied the teachings of Strickberger into the device of Shiki as modified so as to increase the efficiency of the blocker even more, with the well known benefits of MLI as taught in Strickberger.

e. Re Claim 7

Claim 7 is dependent on prior claims, the novelty and inventiveness of which have been outlined previously herein.

Furthermore, even with a solar energy absorptivity of less than 0.5, or other practically achievable levels of absorptivity, on the sun facing surface of sun blocker components, related prior art would still either not work or would have optimum performance greatly lower than achievable with the fundamentally distinct and superior design of the disclosure of Reference R1. See, for example, Appendix 3 for a comparison of heat rejection capability of inventions according to Cited Document D4 and the disclosure of Reference R1 with various characteristics of the sun blocker component.

f. Re Claim 8

Claim 8 is dependent on prior claims, the novelty and inventiveness of which have been outlined previously herein.

g. Re Claim 9

Claim 9 is dependent on prior claims, the novelty and inventiveness of which have been outlined previously herein.

Furthermore, even with a thermal emissivity of less than 0.5, or other practically achievable levels of thermal emissivity, on the sun facing surface of sun blocker components, related prior art would still either not work or would have optimum performance greatly lower than achievable with the fundamentally distinct and superior design of the disclosure of Reference R1.

h. Re Claim 11

Claim 11 is dependent on prior claims, the novelty and inventiveness of which have been outlined previously herein.

6. Re Reference R3, paragraph 6 - "Allowable Subject Matter"

Previously herein we have demonstrated that claims 4-6, 10, and 12-33 are dependent on valid base claims.

7. Re Reference R3, paragraph 7 - "Conclusion"

We note the listings in Reference R3 of prior art made of record and not relied upon but considered pertinent to the disclosure of the disclosure of Reference R1, i.e.:

i. USPN 6,318,673 to Wolters discloses MLI

j. USPN 6,102,239 to Wu et al. discloses a sun blocking device on a spacecraft.

Please note that the referenced item (j) is our priority document, i.e. Reference R2 herein.

Reference R3 paragraph 7 also states: *"Three foreign language European Patents were included with the instant application. If the applicant would like these considered it is suggested that a translation be submitted and IDS filed for them as well as for the 2 US Patents and the "Space Craft Systems Engineering" excerpt. The 3 US Patents and the excerpt have been considered."*

We would like the said three European Patents to be considered.

They are Cited Documents D1, D2, and D4. Of the three, two are in French (Cited Documents D2 and D4) and one in English (Cited Document D1).

The disclosure of Reference R1 is novel and inventive over prior art including Cited Documents D1, D2, and D4 for similar reasons as discussed earlier herein with respect to USPN 4,725,023 to Shiki and for reasons discussed in the following sub-sections of section 7 herein.

7.1 OSRs and Other Reflective Coatings do Not Constitute Thermal-Insulation Means

OSRs or other reflective coatings if present on the sun facing side of a sun blocker component as specified in Cited Documents D1, D2, and D4, would not constitute thermal-insulation means as claimed/stated/implied in said Cited Documents.

Whereas thermal insulation is restriction of flow of thermal energy, reflection is casting back (i.e. diversion or redirection) of energy - which is quite distinct. Note also that application of thermal energy to insulation results in temperature gradients across the insulation, whereas reflection does not. Furthermore, thermal energy absorbed by an OSR or a reflective coating is not restricted from flowing beyond the OSR or coating.

In thermal physics and thermal engineering of spacecraft it would be incorrect to refer to the thermal functions of OSRs or reflective coatings on spacecraft in terms of (a) an expression such as "thermal insulation" as used in claim 1 of the disclosure of Reference R1 as filed or (b) a related derivative expression such as 'thermally insulated' or other related derivative expressions as used elsewhere in the disclosure of Reference R1 as filed, for example in claim 2.

In contrast, in the same context, an expression such as the phrase "thermal insulation material located between the sun-facing surface (111b, 112b) for restricting heat flow through said sun blocker component.....between said sun-facing surfaceand said opposed surface...", as used in claim 1 of the disclosure of Reference R1, denotes considerable and significant impedance of conduction of thermal energy for practical purposes by means of either significant thickness of a medium with low (thermal) specific conductance or a vacuum space.

7.2 Novelty and Inventive Step (Characterisation)

Novelty and inventive step both stem from specification of thermal insulation of the sun-facing surface of the sun blocker component from the opposed anti-sun-facing surface by high performing thermal insulation material located between said surfaces - which results in improvement in the effective radiation view factor from the thermal radiator surface to deep space as can be understood from a reading of sections 7.3 through 7.3.2 herein. (Please note that in English usage the word "surface" denotes "outermost boundary".) In a preferred embodiment, said high performing thermal insulation material is multi-layer insulation (MLI). In contrast, none of Cited Documents D1, D2, D3, and D4 feature thermally insulating material located between the surfaces of a sun screen. Specifically:

- Cited Documents D1 and D4 teach of screens comprised of unspecified materials with unspecified thermal characteristics and optional OSRs or nonspecific external coatings to limit in an unspecified way a nonspecific effect of the Sun on the screen.
- Cited Document D2, throughout, teaches of a sun screen as means of "reflecting the solar light", said screen comprising "a plate of polished aluminium" ... "that assures the rigidity" ... "and, outside of the latter, a layer of material (36)" ... "whose face that is exposed to the Sun is chosen in a reflective material", said layer of material, conversely, being for a purpose of performing a non-specific function of "ensuring the insulation and the reflection of the solar radiation". Thereby, cited document D2 claims reflective means for performing functions of insulating and reflecting (the incorrectness of which is discussed in section 7.1 herein); and nowhere does it provide a statement of means of performing an insulating function.

Therefore, regarding performance of an insulating function cited document D2:

- o is ambiguous;
- o incorrectly describes or misconstrues a reflective material as providing an insulating function, (Please see section 7.1 herein for an explanation of the incorrectness of that.);
- o adds a further measure of vagueness through use of the word "ensuring"; and
- o renders the meaning of claim 4 therein unclear and without technical meaning.

Additionally, regarding cited document D2, please see the concurring statements in the International Preliminary Examination Report for international application number PCT/US/08572, dated 27 September 2000, under 'V. Reasoned opinion under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement, 2. CITATIONS AND EXPLANATIONS, Claim 1, and Claims 2-33', i.e.

"Claim 1

Closest prior art, see amended description page 3/0/1, is EP-A-0 447 049 (GEC-Marconi Ltd.) describing solar panels which are offset from their axes of rotation at the centre of radiator surfaces so that the panels obscure part of the radiator surfaces from the sun's rays, thereby lowering the solar irradiation on the radiator surfaces and increasing efficiency of the radiators. Disadvantageous are: the offset in mechanical terms, as

well as the heat radiated by the solar panels themselves towards the radiator surface.

The subject-matter of amended claim 1 optimises the effective radiation view factor from the radiator surfaces to deep space by means including thermal insulation between a sun facing surface of a blanking panel and an anti-sun-facing surface thereof, thereby inhibiting heat transfer through the blanking panel and thus decreasing heat radiating from the blanking plate to the radiator surface. There is no lead in the prior art to this expedient. Although EP-A-0 271 370 (CNES, see description page 3/0/1) does disclose a sun screen with thermal insulation, this appears to be more by way of a reflective coating on the sun-facing surface of the screen; in addition, the geometry of the screen (closely surrounding the radiator surface) does not give rise to the assumption that a general optimization of the effective radiation view factor from the radiator to deep space is aimed at – rather, the solution disclosed mitigates only one aspect of disturbances to this effective view factor. The requirements of Articles 33(2) and (3) PCT are thus fulfilled; likewise, the requirements of Article 33(4) PCT is fulfilled.

Claims 2-33 depend on claim 1 and likewise fulfill the requirements of Article 33(2)-(4) PCT."

- Cited Document D3 teaches of a screen with no specified thermal-related characteristic/feature whatsoever.

Please see sections 7.3 through 7.3.2 herein for further discussion of distinctions between the inventions according to the disclosure of Reference R1 and Cited Documents D1, D2, D3, and D4.

7.3 Distinguishing Features Claimed

The disclosure of Reference R1 teaches of and claims novel and inventive features that enable high thermal performance of the thermal radiator surface that the relevant prior art does not.

These features are of great importance to thermal performance of the thermal radiator surface, as they result in a high 'effective radiation view factor' from the thermal radiator to space (i.e. they make the sun blocker component virtually thermally-transparent to the thermal radiator surface), by meeting the following requirements for a high performing sun blocker component:

- (C) The materials and construction of the sun blocker component shall be such that said sun blocker component, in operation, shall minimize transference through the sun blocker component of solar energy absorbed by the sun-facing surface and subsequently radiated towards the thermal radiator surface.
- (D) The sun blocker component shall reflect into space the incident thermal energy that originates from the thermal radiator surface.

Both of the preceding requirements are satisfied by high performing insulation material located between the sun-facing and the opposed surfaces of the sun blocker component.

Note that with regard to requirement (D) above, only if there is high performing thermal insulation between said sun facing and opposed surfaces of the sun blocker component can the sun blocker component reflect away a high fraction of thermal energy arriving radiatively at said opposed surface from the associated thermal radiator surface – since said high performing insulation results in a low value of infrared (IR) ‘effective emittance’ of said opposed surface, with a corresponding low value of IR ‘effective absorptance’ and thus a high value of IR ‘effective reflectance’. Please see Appendix 6 for a brief discussion of the relationships between emissivity, absorptivity and reflectivity of sun blocker surfaces.

7.3.1 Assessment of the disclosure of Reference R1 for features enabling satisfaction of aforementioned requirements (C) and (D) in section 7.3 herein

Inspection of the first, independent claim for distinct features satisfying requirements (C) and (D) in section 7.3 herein, reveals that the disclosure of Reference R1 claims novel and inventive characteristics of a sun blocker device (i.e. high performing insulation material located between the sun-facing and opposed surfaces of a sun screen) that are sufficient to satisfy said requirements far better than relevant prior art. Additionally, a dependent claim specifies multi-layer insulation (MLI) for said insulation material, enabling satisfaction of said requirements superlatively.

Multi-layer insulation (MLI), for example as specified in claim 2 of the disclosure of Reference R1 as filed, is a very special type of insulation. (Please see Appendix 4 for a brief explanation of MLI). It is specifically referred to simply as MLI in the English and French languages within the aerospace industry, and sometimes as MLI blanket.

The essential function of MLI as used on exteriors of spacecraft in general is to provide thermal insulation between front and back surfaces, and expressly is not to reflect incident solar radiation by means of external coatings thereon.

With regard to a sun blocker component incorporating MLI as insulation between its surfaces:- extraordinarily low values of (a) front-back thermal conductivity (high front-to-back insulation) and (b) resultant backside emittance result from (c) an extremely low degree of physical contact between adjacent constituent layers of the MLI, together with (d) radiative re-emission of heat from each of the several constituent layers within the MLI. These low values are critical in achieving high or even worthwhile performance from the sun blocking device. (Please refer to Appendix 4 hereto for explanations of MLI and of effective emittance.) Please note that said extraordinarily low values do not result from coatings, if any, on the external surfaces of the MLI.

Additionally, note that the expression “thermal insulation” as used in claim 1 of the disclosure of Reference R1 as filed, and also related derivative expressions used

elsewhere in the disclosure of Reference R1 as filed, are implicitly inclusive of use of materials of low specific thermal conductivity, for example styrofoam (polystyrene foam).

Accordingly, the first independent claim is novel, inventive, and industrially useful.

7.3.2 Assessment of Cited Documents D1, D2, D3, and D4 for features enabling satisfaction of aforementioned requirements (C) and (D) in section 7.3 herein

In contrast, inspection of Cited Documents D1, D3, and D4 for distinct features satisfying requirements (C) and (D) in section 7.3 herein, i.e. looking for specification of screens made of specific materials or of materials with specific thermal-related constructions, specific thermal characteristics, or specific thermal functions, reveals only OSRs and surface finishes (i.e. external coatings), except for which thermal control of the screen is not a feature of said Cited Documents and associated inventions. Regarding Cited Document D2, see section 7.2 herein. None of Cited Documents D1, D3, and D4 mentions thermal insulation at all. In particular:

- Regarding the Claims in Cited Documents D1 and D4, and the Claims and Description in Cited Document D3:
 - The claims in Cited Document D1 are silent on thermal properties of screens.
 - Cited Document D3 is silent on thermal properties of screens.
 - The claims in Cited Document D4 are silent on thermal properties of screens.
- Regarding the Description in Cited Document D1:

Two sentences in the description (and the description only) in Cited Document D1 (p 3, col 2, l 54 - p 4, col 1, l 7) merely mention optional optimisation of unspecified surface properties of a blanking-plate screen, using optical surface reflectors (OSRs) or other unspecified possible variations on thermal finishes. Note that neither said OSRs nor said unspecified surface finishes satisfy the preceding requirements (C) and (D) in section 7.3 herein.

Optical Surface Reflectors (OSRs) and Surface Finishes

The present subsection provides a brief explanation of the relatively poor thermal performance of a screen according the descriptions in Cited Document D1 and D4 including optional OSRs or other nonspecific surface finishes on its sun facing side.

OSRs for application on exteriors of spacecraft are designed to reflect away a major part of the incident solar energy - for example, their solar reflectivity is typically 90% at beginning-of-life (BOL) and 75% after about three years in orbit. The range of reflectivities of other practical, surface finishes goes lower, as for example for white paint. Concomitantly, however, such OSRs and other

surface finishes absorb a considerable and thermally very significant part of said incident solar energy (for OSRs, typically 10% and 25% at BOL and after three years solar exposure in space, respectively) and also have high front-back thermal conductances, and consequently are ineffective as means of insulating the front surface of such a screen from the opposed back surface. (Note that the situation is worse for high emissivity surface finishes, which would not be used alone as they also have high absorptivity. Note also that an OSR comprises a second-surface reflector beneath a transparent layer of high emissivity material.) In contrast, the solar absorptivity of MLI (as for a sun blocker device according to the disclosure of Reference R1) is typically less than 0.05 and the backside effective emittance less than 0.1 through life in orbit.

Consequently, it should be appreciated that regarding effect on thermal performance of the associated thermal radiator surface, a screen with optional OSRs layered on its sun facing side according to the description (and the description only) in Cited Document D1 or a screen with a surface finish (or external coating) on its sun facing side according to the descriptions (and the descriptions only) of Cited Documents D1 and D4 would be vastly inferior to a sun blocker device including high performing thermal insulation material located between the front (sun facing) and back (anti-sun-facing) surfaces according to the invention of the disclosure of Reference R1.

Please see Appendix 3 for a brief comparison of heat rejection capability of a thermal radiator surface in inventions according to (a) Cited Document D4 using screens with no special thermal characteristics and screens with OSRs or various external coatings, and (b) the disclosure of Reference R1 using simple high performing insulation or MLI located between the front (sun facing) and back (anti-sun facing) surfaces of the sun blocker component. The comparisons shown in Appendix 3 demonstrate that performance of the invention according to the disclosure of Reference R1 is fundamentally superior to performance of the invention according to Cited Document D4.

Please note that corresponding heat rejection capabilities of a thermal radiator surface in inventions according to Cited Document D1 (not shown in Appendix 3) would be much poorer even than the heat rejection capabilities of a thermal radiator surface in inventions according to Cited Document D4 as shown in Appendix 3, due to (a) additional heat radiated to the thermal radiator surface from the backside of the solar array, and (b) excessive blockage by the solar array of the field-of-view from the thermal radiator surface to space. (As an aside, OSRs also contribute greatly to mass and are expensive, which is very undesirable.) For these reasons, the invention according to Cited Document D1 does not meet a criterion of industrial usefulness.

- Regarding the Description in Cited Document D4:

A sentence in the description in Cited Document D4 (in p 2, col 2, ll 32-36) merely mentions optional use of nonspecific external coatings on an optional substrate (a multi-layer material or a simple skin) of a screen to limit, in an unspecified way, nonspecific effects of the Sun on the screen and thereby also, in an unspecified way, on the associated thermal radiator surface, and to increase, in an unspecified way, their heat rejection capabilities. Note also that said sentence identifies no specific material or materials with particular thermal-related constructions or thermal characteristics or thermal functions for said optional substrates. Please see Appendix 5 hereto, which presents an analysis of [Cited Document D4, p 2, col 2, ll 32-36] regarding these and related issues.

We note that if a screen is not made of a simple skin, then said screen is likely to be made of a multi-layer material. Accordingly, the unsupported expression "multi-layer material" while, at best, possibly being an indication of a convenient type of structural composition, provides neither indication nor specificity concerning any necessary or advantageous feature of the invention, and certainly not concerning any thermal-related feature, and in particular not concerning insulation between exterior surfaces of the screen.

Also, please note that Cited Document D4 does not mention any thermal insulation let alone multi-layer insulation. The only thermal control of the screen featured in Cited Document D4 is by exterior coatings on the screen.

It appears that said sentence in the description of Cited Document D4 (in p 2, col 2, ll 32-36) is merely an ambiguous, nonspecific, vague and imprecise statement of intent, and has no technical meaning, rendering both said sentence and Cited Document D4 unclear.

Accordingly, at best, the thermal performance of the thermal radiator surface according to Cited Document D4 is no better than that according to Cited Document D1. For a geosynchronous spacecraft according to Cited Documents D1 and D4, the improvement, in said thermal performance, relative to that for a thermal radiator in an unshaded arrangement, are merely narrowing of the range of temperature and slight reduction in peak temperature of the thermal radiator surface – as shown in Appendix 3 hereto.

For important discussions of these points, please refer to an analysis of said sentence (in p 2, col 2, ll 32-36) in Appendix 5 hereto and to the following subsections herein concerning multi-layer material, simple skins, and external coatings.

Multi-layer Material

We note that said term "multi-layer material", includes a vast range of materials, material constructions and material thermal properties – the great majority of which would not provide either (a) suitable high performing thermal insulation between the

front (sun facing) and back (opposed anti-sun-facing) surfaces of a sun screen, or (b) usefully-low backside 'effective emittance' of said sun screen, regardless of whether "suitable external coatings" were present on the multi-layer material.

Examples of multi-layer materials that are commonly and widely used in spacecraft, for their thermal properties as well as their mechanical properties, for example for structural panels, are: graphite-epoxy laminates, and honeycomb-core laminates with aluminium or graphite-epoxy faceplates. In the context of a screen according to the invention of Cited Document D4, all of these multi-layer materials have high thermal conductivity (the opposite of the required thermal insulation) between their front and back surfaces, and would transfer highly significant and critically deleterious solar thermal flux to the anti-sun-facing surface and on to the associated thermal radiator surface. A further illustratively useful example of a multi-layer material is a stack of three mylar sheets, each sheet being generally in physical contact with its adjacent sheet(s) and said sheets being either with or without surface coatings. This example, too, has high front-back thermal conductivity. Its performance is shown as Case 1 in Appendix 3 herein.

Accordingly, and as indicated in sections 7.3 and 7.3.1 and earlier in section 7.3.2 herein, with a screen made of any of any of the example multi-layer materials discussed in the preceding paragraph, thermal performance of the invention according to Cited Document D4 would be diminished to the point of relative practical uselessness for the purpose claimed, due to (a) heat transferred through the screens from the sun facing side and (b) heat radiated from the thermal radiator surface and subsequently returned via re-emission from the backside of the screen, associated with high backside 'effective emittance' of the screen. Please refer to Appendix 3 for relative performance of a thermal radiator surface with a screen made of each of these examples of multi-layer material or other material.

Selection of an insulating material between the sun facing and the opposed anti-sun-facing surfaces of a screen is neither claimed, nor mentioned, nor obvious from any part of the Cited Documents D1, D2, D3, and D4, as also discussed elsewhere herein.

It should be appreciated that the most important functional characteristic of MLI, as claimed in claim 1 of the disclosure of Reference R1 as filed, relative to other materials mentioned in the prior art (including nonspecific multi-layer material as mentioned in the description in Cited Document D4) is its high performing thermal insulation, as mentioned in section 7.3.1 herein and explained in Appendix 4. This insulation characteristic is due to air/vacuum spaces and extremely small path for heat conduction between its constituent layers resulting, typically, from use of Dacron-net separators or from crinkling of the layers to achieve minimal contact between adjacent layers.

Simple Skins

In common usage of language and in our experience of specialist terminology and usage of language in spacecraft engineering, the phrase "simple skin", as used in Cited Document D4 for example, denotes a thin and flexible/pliable sheet or membrane without any other substrate for support. In the context of a screen according to Cited Document D4, a thick or rigid structural composition would not be appropriately referred to as a simple skin.

With regard to steady state illumination by the Sun in a space environment of a front (sun-facing) surface of a sunscreen according to the invention of Cited Document D4 comprising a simple skin as interpreted according to the first sentence of the preceding paragraph, inevitably said skin has significantly high front-back thermal conductance (the opposite of high thermal insulation), regardless of the material and/or external coating(s) of said skin. Consequently said skin is close to isothermal, in operation. Consequently, in practice a major fraction of the solar energy incident on the front surface of such a screen is conducted to the back (opposed anti-sun-facing) surface of said skin and is radiated therefrom towards the associated thermal radiator surface. Consequently, the performance of such a sunscreen is inherently greatly sub-optimal, particularly in comparison with a screen according to the invention of the disclosure of Reference R1.

External Coatings

With reference to common usage of language and to specialist terminology and usage of language in thermal physics and thermal engineering of spacecraft, an expression such as "external coating", as used in the description in Cited Document D4, is synonymous with the term "surface finish" as used in the description in Cited Document D1 and discussed earlier in this section, i.e. section 7.3.2, herein, and denotes a very thin, adherent, outermost layer. Such an external coating would generally have selected values (at least before solar exposure) of solar reflectivity and/or solar/infrared absorptivity and/or infrared emissivity.

As such, an external coating in the context of a screen according to the description in Cited Document D4 does not restrict flow of absorbed solar thermal energy into and through the screen. However, as discussed earlier herein, a major fraction of incident solar energy is absorbed by external coatings. Consequently, the absorbed energy passes through the screen to the opposed surface unimpeded by said external coatings, and is radiated towards the associated thermal radiator surface, thereby reducing the heat rejection capability of the latter. Consequently, the thermal efficacy of the invention according to Cited Document D4 is at best comparable with the thermal efficacy of the invention according to Cited Document D1 and greatly inferior to the thermal efficacy of the invention according to Reference R1.

One might speculate, for example, that the vague description in Cited Document D4 might, perhaps, at best be consistent with a reflective metallic surface finish on the sun facing side of a screen for purposes of reducing the fraction of incident solar energy absorbed by that side. Such an external coating would not, however,

restrict passage of the absorbed solar energy from the front surface of the screen towards the opposed surface, nor would it reduce re-emission, back towards the associated thermal radiator surface, of thermal energy arriving radiatively at said screen from the associated thermal radiator surface.

Consequently, as discussed earlier herein, it should be appreciated that regarding effect on thermal performance of the associated thermal radiator surface, a screen with an external coating on its sun facing side according to the description (and the description only) of Cited Document D4 would be vastly inferior to a sun blocker device including thermal insulation material located between the front (sun facing) and back (anti-sun-facing) surfaces according to the invention of the disclosure of Reference R1.

Please see Appendix 3 for a brief comparison of heat rejection capability of a thermal radiator surface in inventions according to (a) Cited Document D4 using screens with no special thermal characteristics and screens with OSRs or various external coatings, and (b) the disclosure of Reference R1 using simple high performing insulation or internal MLI located between the front (sun facing) and back (anti-sun-facing) surfaces of the sun blocker component.

If necessary do please contact me using the contact information I have furnished at the head of this letter.

Yours sincerely,



Paul F. Kaskiewicz
Common Representative for the Co-Applicants for the Reference R1 US Patent Application

Addenda

Please see the beginning of this letter for lists of the addenda, i.e. Appendices, Amendments, and Translations, that follow.